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When frequent media multitaskers perform worse and when they do not: The role of self-regulation ability and strategy manipulation

Ewa Szumowska [a], Agnieszka Popławska-Boruc [b], Jakub Kuś [c,*], Małgorzata Osowiecka [b], Justyna Kramarczyk [d]

[a] Jagiellonian University in Krakow, Institute of Psychology, Department of Philosophy, Ingardena Str. 6, 30-060, Krakow, Poland
[b] SWPS University of Social Sciences and Humanities, Faculty in Sopot, Polna Str. 16/20, 81-745, Sopot, Poland
[c] SWPS University of Social Sciences and Humanities, Faculty of Psychology in Wrocław, A. Ostrowskiego Str. 30B, 53-238, Wrocław, Poland
[d] Adam Mickiewicz University in Poznan, Institute of Sociology, Faculty of Social Sciences, Szamarzewskiego Str. 89, 60-568, Poznań, Poland

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ABSTRACT

Ophir, Nass and Wagner (2009) showed that as multitasking frequency increases, multitasking performance decreases. Other studies, however, have not replicated this effect (e.g., Minear, Brasher, McCurdy, Lewis & Younggren, 2013). In this paper, we argue that the association between frequent media multitasking and poor multitasking performance depends on self-regulation ability and external factors, such as manipulation of the task execution strategy (sequential vs. free switching). In Study 1, we determined participants' media multitasking frequency and measured their self-regulation ability. Then, participants performed a multiple media task in which they could freely switch between browser tabs. The results showed that high media multitasking levels were associated with more switches between tabs but only for participants with low (but not high) self-regulation ability. No differences in performance were observed. In Study 2, instead of measuring self-regulation ability, we manipulated task execution strategy (as an external form of regulation). As predicted, media multitasking frequency and performance on multiple tasks (overall score) were negatively related only in the free switching condition and not in the sequential condition. The results elucidate the relationship between media multitasking frequency and multitasking performance by showing its boundary conditions, and they help explain contradictory findings in the media multitasking literature.

1. Introduction

Due to the growing importance of new technologies in everyday life and the use of multiple data sources, the potential impact of media multitasking on human behaviour has been under scrutiny for years. Studies have shown that media multitasking has become a predominant media-use behaviour, particularly among adolescents (Brown & Cantor, 2000; Jacobsen & Forste, 2011; Roberts, Foehr, & Rideout, 2005; Voorveld & van der Goot, 2013; Wood et al., 2012). This growing prevalence of media multitasking has negative consequences for cognitive functioning. One popular study by Ophir et al. (2009) showed that compared with light media multitaskers (LMMs, or those low in media multitasking frequency), heavy media multitaskers (HMMs, or those high in media multitasking frequency) were, in fact, worse at multitasking and exhibited difficulties in key areas of cognitive control, such as task switching, filtering, and working memory management. However, other studies (e.g., Alzahabi & Becker, 2013; Minear et al., 2013) did not find a negative relationship between frequent media multitasking and multitasking performance.

In this paper, we argue that the association between frequent media multitasking and poor multitasking performance depends on self-regulation ability and external factors, such as manipulation of the task execution strategy. Ophir et al. (2009) argued that the performance decrements HMMs exhibit might stem from a weak ability to filter out irrelevant, extrinsic stimuli and to ignore unimportant task sets. Therefore, differences in self-regulation (cognitive control) might play an important role in the behaviour of HMMs. Other studies have also shown that individuals who are

* Corresponding author. SWPS University of Social Sciences and Humanities, Faculty of Psychology in Wrocław, A. Ostrowskiego Str. 30B, 53-238, Wrocław, Poland.
E-mail addresses: ewa.szumowska@uj.edu.pl (E. Szumowska), apoplawska1@swps.edu.pl (A. Popławska-Boruc), jkus@swps.edu.pl (J. Kuś), mosowiecka@swps.edu.pl (M. Osowiecka), jkra@amu.edu.pl (J. Kramarczyk).

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low in self-regulation (high in impulsivity) are more inclined to multitask with media (Minear et al., 2013; Sanbonmatsu, Strayer, Medeiros-Ward, & Watson, 2013). These individuals might thus be more likely to exhibit performance decrements related to frequent media multitasking.

We therefore postulated that self-regulation might be an important factor that modulates the relationship between media multitasking frequency and multitasking performance. Specifically, we predicted that high-frequency media multitasking would be related to more task switches and poorer multitasking performance but only for participants who were low in self-regulation ability. By contrast, we expected that participants who were high in self-regulation ability would display no performance decrements. Furthermore, we expected to find similar results when participants' behaviour was regulated externally (e.g., through the manipulation of the task execution strategy) rather than internally.

The studies shed new light on the relationship between media multitasking frequency and multitasking performance by showing its boundary conditions. They also help explain why some studies (e.g., Sanbonmatsu et al.,2013, Ophir et al., 2009) but not others (e.g., Minear et al., 2013)) have observed this relationship. The findings also have implications for how to best design work environments in order to prevent the performance losses that frequent media multitaskers are prone to in computer-based multitasking.

2. Theory

2.1. Media multitasking

In general, media multitasking is defined as engagement in several simultaneous activities, at least one of which must be media related (Popławska, Osowiecka, & Kramarczyk, 2015; Vega, 2009; Zhang, Jeong, & Fishbein, 2010). It might occur on various devices (e.g., using the Internet on laptop and listening to radio) or on a single device, for example, on a computer screen with multiple browser tabs open (Kononova & Chiang, 2015; Lau, 2017; Yeykelis, Cummings, & Reeves, 2014). Furthermore, media multitasking can involve different types of media, including traditional media (e.g., television, radio, newspapers) or new media (internet tools/mobile devices such as laptops, smartphones or tablets; Viitanen, Westman, Kinnunen, & Oittinen, 2012). Some researchers view the majority of computer use as media multitasking (Carrier, Cheever, Rosen, Benitez, & Chang, 2009) and therefore treat computer-based multitasking as a separate category (Benbunan-Fich, Adler, & Mavlanova, 2011; Zhang & Zhang, 2012).

Research has broadly described media multitasking in relation to three main areas: its patterns (Adler & Benbunan-Fich, 2013; Kononova, Alhabash, Park, & Wise, 2012; Rideout, Foehr, & Roberts, 2010), motivations (Kononova & Chiang, 2015; Leung, 2001) and effects (Bowman, Levine, Waite, & Gendron, 2010; Junco & Cotten, 2011; Wang et al., 2012). Studies in the first category mainly focus on what media activities tend to take place concurrently, when and where media multitasking occurs and how people multitask (e.g., parallel vs. interleaved multitasking; Adler & Benbunan-Fich, 2012). Studies in the second category focus on motives, including internal and external – or personal and social – factors that drive multitasking behaviour (Viitanen et al., 2012). Specifically, researchers have observed individual differences in multitasking preferences (Lindquist & Kaufman-Scarborough, 2007), multitasking willingness and the frequency of engagement in multitasking in general and media multitasking in particular. Studies in the third category focus on the outcomes of media multitasking, that is, the consequences of frequent media for a person's cognitive and social functioning (e.g., Bowman et al., 2010; Jeong, Hwang, & Fishbein, 2010; Levine, Waite, & Bowman, 2007; Pool, Koolstra, & van der Voort, 2003; Salvucci & Macuga, 2002). In the current paper, we focus on the third category and examine how reported media multitasking frequency relates to multitasking performance.

2.2. Frequency of media multitasking and multitasking performance

In a popular study, Ophir et al. (2009) examined the relationship between media multitasking and cognition. Their results demonstrated that HMMs have much more difficulties than LMMs in key areas of cognitive control, such as task switching, filtering, and working memory management. The study showed that HMMs were more susceptible to distraction and had greater difficulty filtering out irrelevant, extrinsic stimuli. Moreover, HMMs were less effective in ignoring unimportant task sets, and according to Fox, Rosen, and Crawford (2009), they needed more time to carry out given tasks. Ophir et al. (2009) thus demonstrated an intriguing multitasking paradox: people who multitask to the greatest extent are also those who are affected the most by the cognitive costs of switching between tasks.

Sanbonmatsu et al. (2013) also showed that multitasking activity, measured by the Media Multitasking Inventory and self-reported cell phone usage while driving, was negatively correlated with actual multitasking ability, which was operationalized as performance on the Operation Span task. In line with the findings of Ophir et al. (2009), these results indicate that the people who are most likely to engage in multiple tasks simultaneously are not the people who are most capable of multitasking effectively.

Other studies, however, have failed to replicate these effects. In their study, Minear et al. (2013) tested HMMs and LMMs on measures of attention, working memory, task switching, and fluid intelligence. They also measured their self-reported impulsivity and self-control. They found that people who reported engaging in heavy amounts of media multitasking (HMMs) reported being more impulsive and performed more poorly on measures of fluid intelligence than did those who did not frequently engage in media multitasking (LMMs). However, they did not find evidence to support the contention that HMMs are worse in multitasking situations, such as task switching, or that they show deficits in dealing with irrelevant or distracting information (compared with LMMs).

Similarly, a recent study by Alzahabi and Becker (2013) reported that compared with LMMs, HMMs were not worse at dual-task performance and were in fact better at shifting between tasks. The authors were also unable to replicate Ophir et al. (2009) findings despite using identical task paradigms.

The abovementioned contradictory findings suggest that the relationship between media multitasking frequency and multitasking performance is a complex one, and some additional factors might influence it. We here argue that media multitasking frequency and multitasking performance are negatively related but only when behaviour regulation (understood as either a person's ability or a situational factor) is low. We thus propose a candidate-moderating variable.

2.3. (Self-) regulation and multitasking performance

Self-regulation, often used interchangeably with self-control, is the ability to control one's attention and behaviour in relative autonomy from external pressures, innate and learned automatisms, and physiological impulses (Baumeister & Tierney, 2011; Krug & Carter, 2011; Muraven & Baumeister, 2000; Nęcka, 2005). It manifests itself in the capacity to postpone gratification and override automatic or habitual response tendencies (Bauer & Baumeister, 2011; Nęcka, 2005), and it is necessary for successful goal attainment, especially when obstacles and restrictions appear (e.g., Austin & Vancouver, 1996; Fishbach, Dhar, & Zhang, 2006). Efficient self-regulation thus requires managing competing demands on one's time and resources by striving to achieve desired outcomes while simultaneously preventing or avoiding undesired outcomes (Neal, Ballard, & Vancouver, 2017).

Self-regulation is therefore crucial in efficient multitasking or multiple goal pursuit (e.g., Neal et al., 2017). To pursue several tasks or goals, diverse behavioural tendencies must be reconciled, and activities must be organized in terms of time and importance (Nęcka, 2005). Therefore, effective self-regulation requires the creation and application of a "timetable" for activities (*contention scheduling*; Norman & Shallice, 1986, pp. 1–18). It might also require rescheduling, abandoning a non-attainable goal, or changing a strategy of goal attainment (Neal et al., 2017). Self-regulation is also crucial in ignoring distractions and restraining from engaging in interrupting activities, especially those that are internally triggered, or "self-interruptions" (Adler & Benbunan-Fich, 2013; Katidioti, Borst, & Taatgen, 2014). Failure to ignore distraction (low self-regulation ability) might result in poor performance on multiple tasks (Ophir et al., 2009).

We therefore predicted that self-regulation ability would moderate the relationship between media multitasking frequency and performance. Specifically, we expected that high media multitasking frequency levels would be related to greater engagement in multitasking (more switches between tasks) and poorer task performance but only when participants had low self-regulation ability. High self-regulation ability should enable participants to inhibit the urge to switch and thus prevent decrements in performance. A similar effect should be observed when performance is externally (instead of internally) regulated, that is, when participants' freedom to task-switch is limited.

2.4. Hypotheses

The hypotheses we tested can be formally stated in the following manner:

Hypothesis 1. Media multitasking frequency will be related to more switches between tasks (Hypothesis 1a) and poorer performance on multiple tasks (Hypothesis 1b) only for participants low in self-regulation ability.

Hypothesis 2. Media multitasking frequency will be related to poorer performance on multiple tasks only when participants can freely switch between them (Hypothesis 2a). When behaviour is externally regulated (sequential strategy is imposed), no decrements in performance will appear for frequent media multitaskers (Hypothesis 2b).

We tested these predictions in two studies in which we asked participants to perform a multiple media task. In Study 1, we additionally measured their self-regulation ability, and in Study 2, we manipulated the task execution strategy (in which we either let participants freely switch between tasks or imposed a sequential strategy).

3. Study 1

3.1. Materials and methods

The objective of the study was to examine how the relationship between media multitasking frequency and multitasking performance (both task switches and overall efficiency) depends on self-regulation ability levels. Media multitasking and self-regulation were measured with the use of questionnaires, engagement in multitasking was operationalized as the number of switches between tabs, and multitasking performance was indexed as the aggregated performance on a multiple media task. The last consisted of six individual tasks that involved the use of various media types, such as video, radio broadcast, and on-line articles. These tasks also involved different abilities, such as text comprehension, reasoning, arithmetic, or perceptual-motoric abilities. We looked into how often participants switched between tasks, as task switching is a definitional aspect of multitasking (Delbridge, 2000; Monsell, 2003). We also checked whether there were differences in multitasking performance.

3.1.1. Participants

The sample comprised $N = 53$[1] participants (37 women, 16 men) who responded to a study announcement. The mean age was $M = 30.36$ ($SD = 8.87$; range = 18 to 72). Eight participants had a high school education, fifteen participants were students, and thirty were graduates at the time of the study. Everyone received a monetary compensation equivalent to 2.5 EUR for their participation.

3.1.2. Measures

3.1.2.1. Media multitasking questionnaire. Due to its practical utility and mix of divergent techniques in presented studies, the Short Measure of Media Multitasking was used to examine media multitasking frequency (Baumgartner, Lemmens, Weeda, & Huizinga, 2016). In the first part, the adapted questionnaire assessed time spent per day on three different types of activities: watching television, browsing social media (e.g., Facebook, Twitter, Instagram) and sending messages via phone or computer (e.g., emails, SMS, MMS, IM). In the second part, participants were asked how frequently they used those kinds of media simultaneously. They rated each of the nine items on a scale from 1 (*never*) to 4 (*often*). Following Baumgartner et al. (2016), listening to the radio was added to this short list of media only as a possible secondary activity because it does not require full attention.

To calculate the media multitasking frequency score, we used a formula similar to that of Ophir et al. (2009): we multiplied responses to each media type and the time that a participant reported spending on this media, summed the products and divided the sum by the total time spent on media. We used this score in all data analyses. However, we additionally calculated a raw media multitasking score by summing responses to the nine multitasking items (not adjusting for the total time spent on media) and provide the results for this measure as well (as recommended by Baumgartner et al., 2016).

3.1.2.2. Self-regulation questionnaire. Individual differences in self-regulation ability were assessed with the Short Self-Regulation Questionnaire (Carey, Neal, & Collins, 2004). Example items are *I usually think before I act, I usually keep track of my progress toward my goals*, and *I have trouble following through with things once I've made up my mind to do something* (reverse scored). Respondents answer on a 5-point Likert scale (from 1, *strongly disagree* to 5, *strongly agree*). In contrast to its original longer version (Brown, Miller, & Lawendowski, 1999), the Short Self-Regulation

[1] The original sample included $N = 55$ adults. In the course of the data analyses, two unusual cases were identified using Cook's distance and studentized deleted residuals (Fox, 1991). The two cases were the highest on both Cook's distance and the absolute value of studentized residuals when a regression model predicting the number of switches was tested (the cases had the lowest and highest number of switches, respectively). The data for this study were collected as a part of a larger project and were also used for analyses involving different variables (described in Szumowska, Popławska-Boruc, & Kossowska, 2017).

Fig. 1. Three sample screens from the multiple media task (Sudoku puzzle, air hockey game, and the Terracotta Army article, respectively). The order of the tabs was randomized. In Study 1, participants could start from the tab they selected and switch freely between tasks. In Study 2, only participants in the free switching condition could freely switch between tasks, whereas participants in the imposed condition could move to the next tab only after finishing a task in the previous tab. There was a time limit of 40 min.

Questionnaire produces a one-factor solution to measure an individual's capacity for self-regulation. Therefore, to calculate a general score of self-regulation ability, we averaged the responses to all items. The scales provided a satisfactory reliability (Cronbach's $\alpha = .89$).

3.1.2.3. Multiple media task. To measure media multitasking behaviour, we presented participants with a multiple media task, which consisted of six tasks that utilized various media types and were designed to reflect normal daily activities on the Internet (see Fig. 1).

Participants were presented with six tabs in a Google Chrome browser: 1) an on-line article, 2) an on-line video, 3) an on-line radio broadcast, 4) a Sudoku puzzle, 5) a set of logic problems (e.g., *Marathon is to race as hibernation is to: A. winter, B. bear, C. dream, D. sleep*), and 6) an air hockey game. (The tasks we used were modelled after those used in other studies. For example, Adler & Benbunan-Fich, 2012, 2013, used a Sudoku puzzle and a logical series; Lee, Lin, & Robertson, 2012, used an article and a video). Participants were able to start and stop every task at any moment (most of the tasks had a “pause” button; however, a “pause” button was not necessary in the article and logic problems, as these were reading tasks and could be stopped without it). Hence, participants could easily switch between the activities according to their preferences.

The article, the video (9:38 min) and the radio broadcast (9:14 min) pertained to one topic: the Terracotta Army. We chose this topic because it was neutral and rather interesting to participants.

After the first part of the study was completed, participants were asked to answer a set of questions on the Terracotta Army (5 questions for each media type, i.e., article, video, and radio broadcast). To complete the test, participants had to become acquainted with all three media types because the information presented in the article, video and radio broadcast was different; however, all of the information in these three media types pertained to one topic. The number of correct answers for each media type was used as a measure of performance on each of the three tasks. The measure of performance on the Sudoku puzzle was the level participants reached, ranging from 1 to 6. The measure of performance on the air hockey game was the number of points participants earned. Additionally, we measured the number of logic puzzles participants correctly solved. Similar to other researchers (e.g., Adler & Benbunan-Fich, 2013), we standardized and averaged performance on each task to obtain one general score of multiple task performance.

To measure the number of switches between tasks, we used a special Google Chrome plug-in (Kuś, 2014). The more often participants switched between six open tabs, the higher their score.

3.2. Procedure

The study was run in a laboratory equipped with two computers. Participants were tested in the lab individually. First, they were provided with paper instructions informing them that the study would consist of two parts. The order of these stages was counterbalanced. In one part, participants were asked to fill in an anonymous on-line survey (designed in Google Docs) that contained the demographic questions and questionnaires.[2] There was no time limit for this part. In the other part, participants were presented with a multiple media task on the other computer. The task consisted of six tabs opened in one Google Chrome window. The order of the tabs was randomized. (Each time, the experimenter rolled a die to determine the order of the websites.) There was a time limit of 40 min, which was determined from a pilot study and was set intentionally shorter than the average amount of time a typical user would need to complete the tasks. Time restrictions were in place to avoid idleness in case participants finished the tasks early (Adler & Benbunan-Fich, 2012, 2013). Participants were instructed to wear headphones and perform the presented tasks in the most natural way, as they would perform them at home. They were also told that they could switch between unfinished tasks or work on one after another, depending on their choice. Additionally, they were informed that the order of the tasks, the time devoted to each of them, and when to switch between tasks was entirely up to them. The special plug-in registered participants' activity, and they were asked not to close any tabs. After the 40-min period had elapsed, participants answered the set of questions on the Terracotta Army. Then, participants were debriefed, thanked, and compensated for their participation in the study.

3.3. Results & discussion

Descriptive statistics for all measures used in Study 1 are presented in Table 1. We tested whether every participant completed all tasks to some degree. To test our predictions, we ran a moderation analysis in which we entered media multitasking as an independent variable and self-regulation as a moderator. We separately analysed the number of switches between tasks and multitasking performance (measured with the aggregated

[2] During the study, apart from the media multitasking task and self-regulation questionnaires, participants also filled in another questionnaire that was not relevant to the current research question.

Table 1
Means, standard deviations, and intercorrelations for variables measured in Study 1 (N = 53).

	M	*SD*
1. Media multitasking	22.75	6.23
2. Self-regulation	3.22	0.70
3. Switches between tasks	28.74	15.07
4. Questions from the article	1.66	1.52
5. Questions from the video	1.11	0.85
6. Questions from the broadcast	1.34	0.81
7. Logical puzzles	4.08	1.64
8. Air hockey game [points]	705.32	817.08
9. Sudoku [level]	2.23	1.45

performance score). We ran the moderation analyses with the Process macro for SPSS version 2.13 with 10,000 bootstrap samples for bias corrected bootstrap confidence intervals (Hayes, 2013). To identify significant interactions, we ran simple slopes analyses and calculated the effect of our IV on DV for low, medium, and high values (−1 *SD*, mean, +1 *SD*) of the moderator. To supplement this information, we ran a regions-of-significance analysis using the Johnson-Neyman technique (Johnson & Neyman, 1936). This technique allows the direct identification of points in the range of the moderator variable where the effect of the predictor on the outcome transitions from statistically significant to non-significant.

The results showed that the number of switches between tasks was significantly predicted by both media multitasking, b = 10.96, SE = 4.65, $t = 2.36$, $p = .02$, *95% CI* [1.61, 2.30], and self-regulation, b = 26.00, SE = 11.28, $t = 2.31$, $p = .03$, *95% CI* [3.33, 48.66]. More importantly, however, these effects were qualified by a significant interaction, b = −3.37, SE = 1.41, $t = -2.39$, $p = .02$, *95% CI* [-6.21, −0.54].[3] In line with our predictions (Hypothesis 1a), media multitasking was positively related to the number of switches between tasks but only for participants low on self-regulation; the effect was close to significance at −1 SD (b = 2.45, SE = 1.39, $t = 1.76$, $p = .08$, *95% CI* [-0.38, 5.25]) and reached significance at −1.42 SD (b = 3.44, SE = 1.71, $t = 2.01$, $p = .05$, *95% CI* [0, 6.87]), as indicated by the regions-of-significance analysis. The effect was not significant at the mean, b = 0.10, SE = 0.99, $t = 0.10$, $p = .92$ *95% CI* [-1.88, 2.08], or high values of the moderator, b = −2.26, SE = 1.39, $t = -1.62$, $p = .11$, *95% CI* [-5.06, 0.55]. The interaction is graphically presented in Fig. 2.

The analyses of media multitasking performance showed no significant effect of media multitasking, b = 0.18, SE = 0.16, $t = 1.12$, $p = .27$, *95% CI* [-0.14, 0.50], self-regulation, b = 0.70, SE = 0.39, $t = 1.80$, $p = .08$, *95% CI* [-0.08, 1.48], or the interaction term, b = −0.06, SE = 0.05, $t = -1.18$, $p = .24$, *95% CI* [-0.15, 0.04].

The results thus provide support for the hypothesis that self-regulation moderates the relationship between media multitasking and engagement in multitasking. Higher media multitasking frequency was related to more switches between tabs but only for participants low in self-regulation, whereas participants high in self-regulation were able to refrain from switching between tasks (i.e., Hypothesis 1a was supported). However, we found no differences in overall multitasking performance (i.e., Hypothesis 1b was not supported). This might suggest that media multitasking frequency and self-regulation ability are important in predicting the degree of multitasking participants engage in (number of switches between tasks) but not in predicting performance. The latter might additionally depend on the tasks involved (their difficulty and the type of cognitive abilities they require, e.g.,

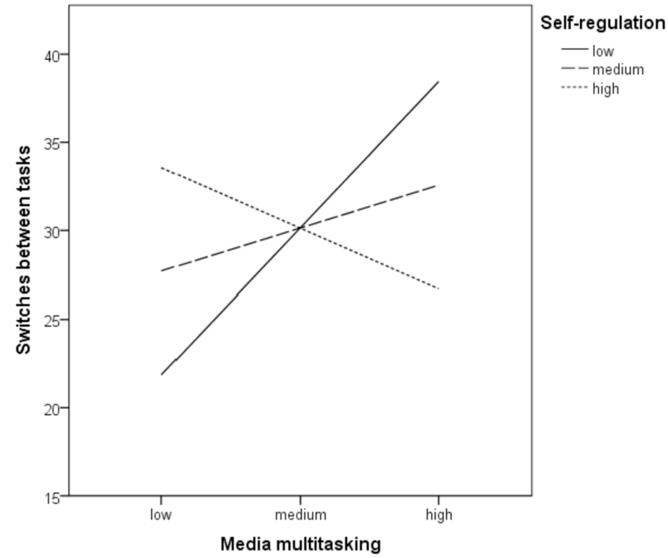

Fig. 2. Relationship between the number of switches between tasks and media multitasking at low (−1 SD), medium (the mean), and high (+1 SD) self-regulation.

Kahneman, 1973; Navon & Gopher, 1978) and participants' cognitive abilities (e.g., König, Bühner, & Mürling, 2005).

4. Study 2

4.1. Materials and methods

The goal of Study 2 was to further test how the relationship between media multitasking frequency and performance on multiple tasks depends on external conditions rather than dispositional self-regulation ability. To that aim, we presented participants with the same multiple media task as in Study 1 and manipulated the task conditions by telling one group of participants that they could freely switch between tasks (the free switching condition) and another group that they had to perform tasks sequentially (the imposed sequential condition). We then checked the relationship between media multitasking and multitasking performance depending on the condition. We predicted that media multitasking would be related to performance decrements but only in the free switching condition and not the sequential one because an external control was exerted in the imposed condition.

4.1.1. Participants

The sample comprised $N = 86$ young adults (57 women, 29 men). Their age ranged from 19 to 49 ($M = 27.10$, $SD = 8.15$). Seventy participants were students, ten had already graduated, and six did not have a higher education. Participants were recruited by an announcement or through personal contacts. They received a monetary compensation equivalent to 2.5 EUR for their participation in the study.

There was one case with incomplete data and an outlier diagnostics (Fox, 1991) indicated two unusual cases (with the highest Cook's distance and the absolute value of studentized deleted residual). The cases were removed from further analyses (and the results with these cases included are also reported). The final sample comprised $N = 83$ participants (54 women, 29 men).

4.1.2. Measures

The same Media Multitasking Questionnaire and the same multiple media task used in Study 1 were used in this study.

[3] The results were similar when the raw media multitasking score was used, b = −1.24, SE = 0.47, $t = -2.62$, $p = .01$, *95% CI* [-2.18, −0.29].

However, this study included two conditions: free switching and imposed. In the free switching condition, participants could start with a tab of their choosing and freely switch between tabs. In the imposed sequential condition, participants were asked to perform tasks sequentially.

4.2. Procedure

The procedure was similar to that of Experiment 1, but we manipulated the instructions in the multiple media task. One group of participants was instructed to perform the multiple media task in the most natural way, as would perform them at home. This was called the free switching condition. Another group of participants was instructed to perform the multiple media task in the order given by the experimenter. They could not decide about the order in which they performed the tasks, and after finishing a task, they could not return to it later. This was called imposed sequential condition. The order of the task was randomized. (Each time, the experimenter rolled a die to determine the order of the tabs.) This procedure was used to minimize the influence of individual preferences on the types of tasks selected and to avoid a situation wherein one tab was chosen as the first one more often. Therefore, every participant had a randomized order of tabs. Participants were randomly assigned to conditions.

4.3. Results & discussion

The descriptive statistics for variables measured in Study 2 are presented in Table 2. To test our hypotheses, we ran a moderation analysis. As in Study 1, we used a Process macro for SPSS (Hayes, 2013). Media multitasking was the independent variable, and condition was the moderator. The free condition was coded as 1 and the imposed condition as 2. This time, we analysed only performance, as the number of switches between tasks was determined by the condition participants were in. (The difference between conditions was highly significant, $t(82) = 13.81$, $p < .001$.)

The results showed that performance on multiple tasks was predicted by media multitasking frequency, $b = -0.22$, $SE = 0.09$, $t = -3.40$, $p = .02$, *95% CI* [-0.41, −0.04], and condition, $b = -1.23$, $SE = 0.53$, $t = -2.33$, $p = .02$, *95% CI* [-2.28, −0.18]. These effects were also qualified by a significant interaction, $b = 0.14$, $SE = 0.06$, $t = 2.41$, $p = .02$, *95% CI* [0.02, 0.25].[4] The interaction indicated that media multitasking was negatively related to multitasking performance in the free switching condition, $b = -0.08$, $SE = 0.04$, $t = -1.97$, $p = .05$, *95% CI* [-0.16, 0].[5] This provides support for Hypothesis 2a. The effect in the imposed sequential condition was positive but not significant, $b = 0.06$, $SE = 0.04$, $t = 1.43$, $p = .16$, *95% CI* [-0.02, 0.14], thus supporting Hypothesis 2b.

Thus, in line with our predictions, media multitasking frequency was negatively related to multitasking performance but only in the free switching condition. In line with previous studies, this finding demonstrates the negative consequences of frequent engagement in media multitasking (Ophir et al., 2009; Sanbonmatsu et al., 2013). However, it was non-significant in the imposed sequential condition, which suggests that there are some conditions in which high media multitasking frequency might not be related to performance decrements.

[4] The results were similar when the raw media multitasking score was used, $b = 0.07$, $SE = 0.03$, $t = 2.63$, $p = .01$, *95% CI* [0.02, 0.12].

[5] The effect is equal to $b = -0.04$, $SE = 0.02$, $t = -2.04$, $p < .05$, *95% CI* [-0.08, −0.001], when the raw media multitasking score is used.

Table 2
Means and standard deviations for variables measured in Study 2 (N = 83).

	M	*SD*	*M*	*SD*
1. Media multitasking	17.71	3.89		
Condition	Free		Imposed	
2. Switches between tasks	55.58	24.11	–	–
3. Questions from the article	2.15	1.25	2.31	1.11
4. Questions from the video	2.17	1.42	2.44	1.52
5. Questions from the broadcast	2.56	1.34	2.31	1.12
6. Logical puzzles	4.40	1.72	4.08	1.79
7. Air hockey game [points]	1478.48	1125.41	1254.97	1044.52
8. Sudoku [level]	1.52	1.41	2.33	1.74

5. General discussion

Multitasking has become a common part of our everyday lives. A growing number of studies have shown the effects of media multitasking on performance, but few have concentrated on the factors that explain this relationship. In two studies, we investigated whether the internal and external regulation of multitasking behaviour moderated the relationship between media multitasking frequency and performance. To that aim, we measured participants' self-regulation ability in Study 1 and manipulated task execution strategy in Study 2. In both studies, we also measured participants' media multitasking frequency and asked them to perform a multiple media task. We expected high media multitasking frequency levels to be related to a greater engagement in multitasking (more switches between tasks) and poorer performance – but only when participants had a low self-regulation ability (Study 1) and when they could freely switch between tasks (Study 2). We expected no performance decrements for participants with high self-regulation ability and when participants' behaviour was externally regulated (imposed sequential condition). The results supported our predictions.

Specifically, the results of Study 1 revealed that high levels of media multitasking frequency were related to more switches between tasks but only for participants low in self-regulation ability. Participants high in self-regulation were able not to switch between tasks. (The relationship between media multitasking frequency and multitasking performance was non-significant.) However, media multitasking frequency was not related to differences in multitasking performance. Although inconsistent with our predictions, this effect is in line with other findings. For example, Junco and Cotten (2012) revealed that while using Facebook and writing on-line messages were connected with worse academic performance, searching for information on-line was not. Studies have also shown that using situational cues and consulting many different sources of information are connected with higher creativity levels, which is one performance indicator (Runco, 1999). Moreover, Adler and Benbunan-Fich (2012) showed that the relationship between switches and performance is complex. They demonstrated that multitasking (measured with discretionary task switching) is negatively related to performance effectiveness, but they observed an inverted-U pattern for performance efficiency, where medium multitaskers perform significantly better than both high and low multitaskers. This suggests that other variables, such as participants' abilities, task characteristics, or performance aspects, might play a role in understanding the relationship between media multitasking frequency and performance and how it is influenced by self-regulation ability. Future studies are required to further examine this matter.

Our results show that self-regulation is an important dispositional determinant of how efficiently people manage multiple tasks. This finding is in line with Rosen, Carrier, and Cheever's (2013) proposal that the effect of media multitasking can be controlled by metacognitive strategies that enable better regulation in task performance. It is also in line with other studies emphasizing the role of self-regulation ability in engagement in media multitasking behaviour. For instance, Minear et al. (2013) found a negative relationship between self-control and engagement in media multitasking and a positive relationship between impulsivity and engagement in media multitasking. Sanbonmatsu et al. (2013) found similar results, reporting a positive correlation between impulsivity (behavioural disinhibition; Barratt & Patton, 1983) and media multitasking. Moreover, Jeong and Fishbein (2007) found sensation seeking (also related to weaker inhibition and self-control) to be predictive of media multitasking behaviour in teenagers, and König, Oberacher, and Kleinmann (2010) reported a positive relationship between impulsivity and multitasking behaviour at work. Furthermore, Adler and Benbunan-Fich (2013) argued that self-regulation strategy can help people ignore irrelevant stimuli and refrain from engaging in self-interruptions. These effects are in line with the results we obtained. In Study 1, media multitasking frequency was related to more switches between tasks but only for those low in self-regulation. This suggests that engaging in media multitasking behaviour might in fact stem from lower self-control (see also a study by Loh & Kanai, 2014, who showed that high media multitasking frequency was associated with smaller grey-matter density in the anterior cingulate cortex, the brain region responsible for self-regulation). The above results also show that self-regulation (or other related variables, such as impulsivity or disinhibition) play a crucial role in engagement in multitasking (rather than performance). This might explain why in Study 1, we obtained significant effects only for task switches and not overall performance.

The results of Study 2 further showed that the relationship between media multitasking frequency and performance also depended on external factors. Specifically, it turned out that media multitasking frequency was negatively related to multitasking performance but only in the free switching condition. By contrast, in the imposed sequential condition, the relationship was non-significant; this finding suggests that performance decrements are not always related to frequent media multitasking. The results are thus in line with Ophir et al. (2009) suggestion that differences in the performance of HMMs and LMMs are related not to a deficit but to a cognitive orientation (which might not affect performance when participants are not multitasking, or task-switching).

Our results also suggest that when people are asked to behave in an imposed way, media multitasking frequency and media multitasking performance are not negatively related (we obtained a positive yet not significant relationship). We should note, however, that some studies have shown the opposite effect. Adler and Benbunan-Fich (2012) showed that creativity of solutions, one indicator of effectiveness, was the greatest when participants could freely switch between tasks. In their study, people who intentionally and frequently switched between tasks demonstrated greater creativity in imagining solutions. At the same time, however, frequent switches were associated with a lower solution accuracy. The latter finding is in accordance with our results (poorer performance related to frequent media multitasking in the free switching condition), and it is understandable since our task measured the accuracy – rather than the creativity – aspect of performance.

The results we obtained are also in line with other studies demonstrating the influence of different strategies on performance. For instance, Shin, An, and Kim (2015) examined the use of a second screen to improve learning process and manipulated the way participants used a main (computer) and a secondary (smartphone) screen to perform tasks: in one condition, they used the screens simultaneously and in the second condition they used them in sequence. The authors found that participants appraised their anxiety levels as lower and competence beliefs as higher in the sequential media multitasking condition. In other words, participants found the tasks more difficult and anxious when they were asked to use both screens simultaneously. They also believed they performed poorer in that condition. Furthermore, the authors found a significant interaction between the strategy (simultaneous vs. sequential) and the type of a secondary task participants performed (open vs. closed). In the open task, participants could freely learn the content using the back and forward action on the application. In the closed task, their freedom was limited (the back action was not available and the remaining time for learning was displayed). So, the closed task included some forms of external control over the presentation of information. The results showed that when participants were using the screens simultaneously, they exhibited better performance (memorized the contents more efficiently) when they also performed the closed task (i.e., in the regulated condition). However, when participants used the second screen sequentially, they exhibited better performance in open tasks. The results are in line with our studies as they show that both, limiting one's switching freedom and imposing some external restrictions on the task execution, can result in better performance. Shin et al. (2016) findings, however, show that the positive effects of these restrictions might work to an extent (participants in sequential condition performed better in open tasks). Exploring the optimal conditions for performing different kinds of tasks would be a good direction for future studies.

5.1. Implications & applicability of the results

In our studies, we focused on media multitasking. We presented participants with tasks involving multiple media sources and measured their performance on these tasks. Although media today are a very common source of multitasking (e.g., Ophir et al., 2009; Rosen, Carrier, & Cheever, 2013), they are not the only source. Since multitasking refers to performing two or more tasks at the same time or frequently switching between multiple tasks (e.g., Bühner, König, Pick, & Krumm, 2006; Rubinstein, Meyer, & Evans, 2001; Salvucci & Taatgen, 2011), multitasking can refer to a variety of activities and their combinations, e.g., listening and taking notes, cooking and watching a child or talking on the phone while driving (e.g., Kaufman, Lane, & Lindquist, 1991; Salvucci & Taatgen, 2011; Sanbonmatsu et al., 2013). Since these task combinations are different from the ones we used here, it would be good to test whether our results can be generalized to other forms of multitasking; that is, it would be useful to investigate whether our results extend beyond computer-based multitasking with media. Future research in this direction is needed.

Nevertheless, researchers argue that an increasing number of activities are becoming media and technology dependent; e.g., more often, notes are taken electronically, people frequently use computers during workplace meetings (Benbunan-Fich & Truman, 2009) and students prevalently use their computers or other electronic devices for learning in class (e.g., Ravizza, Uitvlugt, & Fenn, 2016). Furthermore, our communication is increasingly mediated by electronic devices (e.g., Pea et al., 2012). Thus, our results may also apply to a wide range of everyday activities, especially since the tasks we used resemble some tasks people are often required to perform at work. Specifically, the participants in our studies were asked to solve an adding and counting task (Sudoku puzzle), which might represent subtasks performed in numerical spreadsheet applications; the reading task (online article) might represent reading web pages, emails, or instant messages; and the reasoning task (logic problems) might represent analysing available information and making decisions while (or in between) performing other tasks (see Bailey & Konstan, 2006, for a similar task selection). Hence, our results might also pertain to other computer-based activities (not necessarily those that are performed via a Web browser). This is especially important given that survey evidence suggests that computer activities are by far the most multitasked and given that the majority of computer usage is in fact media multitasking (Carrier et al., 2009; McFarlane, 1998; Zhang & Zhang, 2012).

Therefore, we can also expect that for broad categories of computer-based multitasking (not only web-based activities), high self-regulation ability should counteract the tendency of frequent media multitasking to engage in switches between tasks, or multitasking, especially when multitasking is not required (e.g., when using a computer for distraction instead of using it for a compliant use, that is, for a given task) or when multitasking is a result of (self-) interruption (e.g., Adler & Benbunan-Fich, 2013). As for the latter, there is a large body of literature on interruptions and their detrimental effects on productivity (e.g., Bailey & Konstan, 2006; Benbunan-Fich & Truman, 2009; Czerwinski, Cutrell, & Horvitz, 2000, pp. 71–76; Gonzalez & Mark, 2004; McFarlane & Latorella, 2002; Monk, 2004; Monk, Trafton, & Boehm-Davis, 2008; Rubinstein et al., 2001), and as noted earlier, it has been argued that those who multitask frequently are the most prone to these detrimental effects (Ophir et al., 2009; Sanbonmatsu et al., 2013). Our studies show that those who frequently multitask are not necessarily more susceptible to performance decrements, but that this is dependent on their self-regulation ability. Furthermore, the results of our second study showed that external regulation plays a similar role. This is in line with the recommendations of other researchers (e.g., Hallowell, 2005; McFarlane & Latorella, 2002) and experts (e.g., Harvard Business Review, 2009) who, to boost one's productivity, encourage the use of external regulation strategies, such as working in uninterrupted time intervals before turning to interrupting activities, creating do-lists designed to minimize engaging in unplanned disruptive activities, or turning off the sources of interruption by shutting office doors or switching to the "do not disturb" mode on one's electronic devices.

Likewise, our results speak in favour of various computer applications designed to control and minimize interruptions, and hence prevent losses in performance. As a form of external regulation, such solutions can be useful, especially for those who multitask frequently on a daily basis and are thus more prone to performance decrements related to their multitasking orientation (Ophir et al., 2009). The need for such attention-aware systems, or attention managers, has been also emphasized by other researchers (e.g., Bailey & Konstan, 2006; McFarlane & Latorella, 2002; Speier, Valacich, & Vessey, 1999). Bailey and Konstan (2006) argued that the aim of such systems would be to computationally balance a user's need for minimal disruption with an application's need to effectively deliver information. Therefore, an attention manager reasons about when peripheral information should be presented and defers presentation until a user reaches appropriate points during task execution, thus mitigating task disruption. Speier et al. (1999) also emphasized the need for building some features into information system applications or desktops to alleviate the effects of interruptions on computer-based tasks, and McFarlane and Latorella (2002) suggested potential approaches to user-interface design to help people effectively manage interruptions. Again, our studies suggest that such solutions might be particularly effective for those who frequently multitask but who at a given time need to work on tasks requiring their undivided attention.

We should also note, however, that switching between tasks and getting interrupted is not always detrimental. Researchers argue that successful job performance often depends on people's abilities to constantly monitor their dynamically changing information environments, supervise background autonomous services (McFarlane & Latorella, 2002), and communicate with others and obtain "insightful" information from unplanned meetings (which is especially relevant for managers, Souitaris & Maestro, 2010). In a similar manner, Burgess (2000) argues that one of the crucial features of everyday multitasking is adjusting behaviour to unexpected interruptions and changes. Furthermore, previous research shows that multitasking boosts one's creativity (e.g., Adler & Benbunan-Fich, 2012; Runco, 1999) and that a higher frequency of media multitasking is correlated with better multisensory integration (Lui & Wong, 2012). The authors of the latter study argue that frequent media multitaskers have extensive experience integrating information from different modalities, which results in better performance in multisensory integration tasks. Therefore, restricting one's multitasking might be related to some losses in performance, especially when creativity or multisensory integration is required (e.g., when information on the same topic is presented via different channels or modalities). Therefore, restricting task switching might not always be the best and most productive solution; instead, adjusting performance strategies (multitasking vs. focusing on one task at a time) depending on the type of task to be performed or the goal to be obtained seems to be most desirable. The latter lies in the domain of self-regulation ability (responsible for adjusting strategies for current goals, Neal et al., 2017; Rosen et al., 2013). These findings yet again emphasize the role of self-regulation in handling multiple tasks.

5.2. Limitations & future research directions

Our studies also had some limitations. First, the results show that dispositional self-regulation and regulation in the form of external factors modulate the relationship between media multitasking frequency and performance in different ways: self-regulation ability appeared to be a significant moderator in the case of task switches but not performance, and external regulation was a significant moderator of performance (task switches were not analysed in relation to external regulation, and they were directly related to the strategy manipulation we used). Therefore, future studies are required to test the effects of the two types of regulation. It would also be good to measure both in one study in order to understand which one is more important in explaining the impact of media multitasking on multitasking performance.

We also used rather easy tasks. Some of the tasks (e.g., Sudoku) were more cognitively demanding than others (e.g., the air hockey game), but in general, the tasks were not too overloading. In addition, the participants had enough time to complete most of the tasks. This might explain why in Study 1, differences in the number of switches did not go hand in hand with differences in the scores obtained in the task. However, differences in performance appeared in Study 2. This suggests that differences in performance would be even more likely to appear in more demanding tasks. There are certain activities when even the smallest differences in performance or reaction latencies can have huge consequences, e.g., while driving. For instance, Lee, Caven, Haake, and Brown (2001) showed that reaction times as short as 300 ms can substantially increase the odds of a collision. Quick switches between tasks, or task interleaving, is a common behaviour observed in other contexts, such as emergency rooms (Chisholm, Collison, Nelson, & Cordell, 2000) and aviation cockpits (Loukopoulos, Dismukes, & Barshi, 2001). In such contexts, additional time costs when shifting cognitive focus can have significant ramifications. Therefore, studying the effects of frequent media multitasking on performance in more cognitively demanding and safety-critical tasks would be recommended. These studies would not only help to examine whether the effects we here presented generalize to these domains but also identify conditions where negative consequences do not appear.

6. Conclusions

Previous research has shown that frequent media multitasking is not always related to poor multitasking performance. Our results show that this relationship depends on self-regulation ability and external factors, such as task execution strategy. We found that media multitasking frequency was related to more switches in a multiple media task but only for those low in self-regulation and that media multitasking frequency was related to poorer multitasking performance but only when participants could freely switch between tasks. When participants had to work sequentially, their media multitasking and multitasking performance were not related. The present findings elucidate the contradictory findings in the literature and our understanding of how we can most efficiently handle many tasks simultaneously.

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